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COMPARISON OF THE CARBONIFEROUS AND PERMIAN FORMATIONS OF NEBRASKA AND KANSAS.[1] II.

THE WABAUNSEE FORMATION.

Nebraska City.— On account of the historic interest attached to the Nebraska City section care was taken to examine the particular exposures studied by Marcou, Meek and Hayden. As a result of this study I have no hesitation in stating that I fully agree with Meek in referring the lower beds of the section (divisions *A* and *B* of Marcou and Meek) to the Upper Coal Measures (Missourian series).[2] On the geological "Map of Nebraska and Dakota" accompanying this report, the Permian is represented as entering the state from Kansas in Jefferson county, west of the Big Blue Valley, then extending to the northeast as a narrowing belt across Lancaster county and down the valley of Saline Creek to the Platte River and thence up the Platte River to Fremont. The town of Lancaster near the present city of Lincoln in Lancaster county, which is the next county west of Otoe, is represented as about halfway across this Permian area. However, in general, on this map the Permian is represented too far to the west, as for example in the Smoky Hill Valley in Kansas, the *base* is represented as near the city of Salina, which in fact is very near the *top;* while the system is mapped as extending some twenty-five miles west of Salina, nearly all of which is now known to belong in the Cretaceous. The same is true in reference to the northern tier of counties where the Permian was represented in Washington and Republic counties in what is known to be Dakota and Ft. Benton. Further-more, it is perfectly clear that the upper part of the section

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[1] Continued from p. 16, this JOURNAL.

[2] See the Nebraska City section of Meek in Fin. Rep. U. S. Geol. Sur. Neb., etc., pp. 101, 102.

(divisions *C* and *D*), in reference to the correlation of which Meek was in some doubt,[1] also belongs in the Missourian. Meek plainly saw that there was no basis for referring the upper part of the section to one formation and the lower part to another, for he said: "I can see no reason whatever for drawing any important line of division between the beds included in *C* and those of *B*, or for separating either from the Coal Measures,"[2] though in the closing part of the report he was not sufficiently confident to make an unqualified statement to that effect. However, sections in higher rocks to the north and west of Nebraska City, which will be described farther on in this paper, show conclusively that all the Nebraska City rocks belong in the Missourian.

Meek gave a very complete list of the fossils from divisions *B* and *C* at the former Nebraska City landing (near the present Burlington and Missouri River railroad bridge) which are mostly well-known Upper Coal Measure species.[3] A short distance south of this locality is the quarry of the Nebraska City Vitrified Brick Co. which uses about twenty feet of the upper shales of division *C* of the sections of Marcou and Meek. These shales are mostly of a drab color, somewhat micaceous as well as clayey, and resemble those used for vitrified bricks at the Topeka, Kansas, works. Above the shales of the quarry are ten feet of very sandy shales, changing to soft sandstones, which represent division *D* of the early sections. On the farm of the Hon. J. Sterling Morton, about seventy-five feet above the level of the Missouri River, and again on the river bank one mile below the Nebraska City landing and thirty feet above river level, Meek found a stratum of "black bituminous shale, with a few inches of coal" having a total thickness of one foot, six inches, which was not shown in the Nebraska City section and which he thought must belong above it.[4] The position of this shale has an important bearing upon Meek's correlation, for in an argillaceous limestone immediately above the black shale he found a fauna which "agrees exactly, so far as they go, with that of division *B* of the section [its lower part] at the landing, with the exception of *Fusulina*."[1] Since the time of Meek's exploration, the construction of the B. & M. R. R. R. along the river bluff below the old steamboat landing has exposed the rocks and shown Meek's supposition regarding the position of the shale to be correct. The following section is shown above the railroad at some distance below the Vitrified Brick quarry:

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[1] Fin. Rep. U. S. Geol. Sur. Neb., etc., p. 130.

[2] *Ibid.*, p. 103.

[3] *Ibid.*, p. 101; also see "Tabular list," pp. 124–127.

[4] *Ibid.*, pp. 103, 104.

	Feet.
8. Massive somewhat calcareous sandstone	$2\frac{1}{2}=37\frac{1}{2}$
7. Rather arenaceous shales	$15=35$
6. Limestone with fossils, *Fusulina cylindrica*, etc. (No. 3 of Meek's section on p. 103 of his report)	$1\frac{1}{12}=20$
5. Black, very bituminous shale with thin layers of coal, one foot, eleven inches (No. 2 of Meek's section)	$1\frac{11}{12}=18\frac{11}{12}$
4. Mainly argillaceous shales	$9=17$
3. Arenaceous shales, with thin, irregular sandstone at top	$5=8$
2. Massive, soft and friable brownish sandstone (about railroad level) 2 and 3 equal division *D* of Meek's section	$3=3$
1. Argillaceous shales that furnish material for the vitrified bricks (the upper part of division *C* of Meek)	$3=$

Numbers 2 and 3 of the above section form division *D* of Meek's section. If the sixty-nine feet measured by Meek, which are below No. 4 of the above section, be added to it there will be a thickness of ninety-eight feet of Palæozoic rocks for the river bluff below Nebraska City. The rocks may be traced along the bluff continuously the greater part of the distance from the Vitrified Brick quarry to the above section, which shows that the stratum of shale and coal is above the sandstone (division *D*) of Meek's section as he supposed.[2]

The dip in the bluff where the above section was measured is nearly 1° to the east of south. From the rocks just above and below the black shale and coal in the quarry and along the bluff to the south the following species were collected. Meek spent nearly a week in the vicinity of Nebraska City, and made a practically complete list of the fossils of that region. No attempt was made to duplicate his work, and only the few species noted below were collected:

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[1] Fin. Rep. U. S. Geol. Sur. Neb., etc., p. 103.

[2] See Meek's discussion of the stratigraphic position of this coal on p. 104 of his report.

Productus (*Marginifera*) *splendens* Nor. & Pratt (c). Meek referred this to *P. longispinus* Sow. with which identification Keyes agrees, and probably this is correct.

Productus costatus Sowb. (rr).

Productus punctatus (Martin) Sowb. (rr).

Spirifer cameratus Morton (?) (rr). Imperfectly preserved specimen.

Chonetes granulifera Owen (rr).

Enteletes hemiplicatus (Hall) H. & C. (rr). Formerly *Syntrilasma hemiplicatus* (Hall) Meek & Worthen.

Edmondia sp. (rr). The specimen has rather high beak but is narrower than the figures compared, with quite sharp concentric lines.

Macrocheilus intercalaris M. & W. (rr) var. *pulchellus* M. & W. changed by Keyes to *Sphærodoma medialis* (M. & W.) Keyes.

Fusulina cylindrica Fischer (c).

Cythere nebrascensis Geinitz (?) (c).

Meek found *Spirifer cameratus* in the limestone above the coal associated with plenty of other fossils characteristic of the Upper Coal Measures, so that it is clearly shown by the stratigraphy and palæontology that all of the Palæozoic rocks in the vicinity of Nebraska City belong in the Upper Coal Measures (Missourian) instead of in the Dyas (Permian) as claimed by Marcou. The writer is not confident whether the Nebraska City beds should be referred to the upper part of the Missouri formation or to the Wabaunsee formation of the Missourian series. However, the faunal and lithologic characters of the beds near Nebraska City agree quite closely with those of the lower half of the Wabaunsee formation as shown along the Kansas River above Topeka, and so the writer refers them provisionally to it.

Dunbar.—This station on the B. & M. R. R. R. is eleven miles west of Nebraska City and nearly 150 feet higher than the Missouri River at that point. One mile south and one and one-half miles east, or about two miles southeast of Dunbar, on the south side of the B. & M. R. R. R., is the McCartney quarry.

The rocks are well exposed nearly to the level of the railroad, which is about 140 feet higher than the Missouri River at Nebraska City, and above it is a section fifty feet in thickness. The base of this section must be considerably higher than the top of the one at Nebraska City unless there be a reversal in the direction of the dip from that noted there.

SECTION OF THE M'CARTNEY QUARRY.

		Ft. In.		Ft. In.
11.	Soil	4	=	56
10.	Yellow, very fossiliferous shales. *Spirifer cameratus*, etc.	1	=	52
9.	Slightly reddish shales	1 9	=	51
8.	Yellowish shales with thin, greenish-gray layers of rather hard limestone which contain abundant specimens of *Myalina perattenuata* and *Pleurophorus occidentalis*. A little black shale	6 3	=	49 5
7.	Yellowish, rather soft limestone containing fossils. The quarry stone 1 foot 2 inches thick	1 2	=	43 2
6.	Yellowish and drab to greenish argillaceous shale	6	=	42
5.	Red argillaceous shale	2	=	36
4.	Drab to bluish very soft argillaceous shales	11	=	34
3.	Yellowish and rather coarse shales	7	=	23
2.	Shaly yellowish limestones	3+	=	16
1.	Yellowish to drab shales for the upper part; below are reddish shales and the base is covered	13	=	13

(Railroad level about 140 feet above Missouri River at Nebraska City, or approximately 1050 A. T.)

No. 7 of the above section is a rather soft limestone averaging a little more than one foot in thickness which is used to some extent for foundation and abutment work. This limestone contains some fossils, mostly large Lamellibranchs, as for example:

Myalina subquadrata Shum.
Allorisma subcuneatum M. & H.
Aviculopecten occidentalis (Shum.) M. & W.

The greenish gray slightly arenaceous limestones of No. 8 contain abundant specimens of two specimens of Lamellibranchs. The species collected are:

Pleurophorus occidentalis M. & H. (aa). Many of the specimens are external impressions, showing only the concentric lines ; one shows radiating lines somewhat indistinctly and there are a number of internal impressions which show very clearly the furrow made by the interior ridge.

Myalina perattenuata M. & H. (a).

Aclis Swalloviana (Geinitz) M. & H. (?) (rr).

The yellow shales above the quarry stone are quite fossiliferous, No. 10 especially. From these shales of Nos. 8 and 10 the following species were collected, the larger number, however, coming from No. 10:

Chonetes granulifera Owen (aa)

Chonetes lævis Keyes=(*Chonetes glabra* Geinitz) (c). Some of the specimens are worn and show the radiating fibrous shell structure.

Hustedia mormonii (Marcou) H. & C. (c).

Spirifer (*Martinia*) *planoconvexus* Shum. (aa).

Spirifer cameratus Morton (c).

Spiriferina kentuckensis Shum. (rr).

Athyris (*Seminula*) *subtilita* (Hall) Newb.

Productus longispinus Sowb.=(*P. splendens* N. & P.) (r).

Productus cora d'Orbigny (c).

Productus nebrascensis Owen (rr).

Productus semireticulatis (Martin) de Kon. (c).

Productus symmetricus McChesney (rr).

Enteletes hemiplicatus (Hall) H. & C. =(*Syntrelasma hemiplicatus* (Hall) Meek) (rr).

Orthis carbonaria Swallow (?) (rr). Small specimen that seems to be *Orthis* instead of *Enteletes.*

Derbya crassa (M. & H.) H. & C. (rr).

Lophophyllum proliferum (McChes.) Meek (c).

Rhombopora lepidodendroides Meek (a).

Fistulipora nodulifera Meek (aa).

Zeacrinus (?) *mucrospinus* McChesney (r).

Archæocidaris sp. spines and plates (c).

Crinoid stems (r).

Coral sp. (rr). A small branching coral something like *Aulopora.*

Spirifer cameratus Morton as well as numerous other Upper Coal Measure shells are common in these upper yellow shales. The faunal and lithologic characters of the section agree closely with those of the Wabaunsee formation, to which it is referred. Inasmuch as the rocks of this section are still higher than any of those exposed at Nebraska City we have conclusive proof that no part of that section belongs in the Permian. Time did not permit me to continue this section as far west as the Cretaceous; but in the soil and on the surface to the south and west of Dunbar are numerous loose specimens of the brownish-red Dakota sandstone.

CASS COUNTY.

THE WABAUNSEE FORMATION.

Nehawka.—Directly north of Otoe county is Cass county, whose eastern border is formed by the Missouri River, and the greater part of the northern by the Platte River. In the southern part of the county is Weeping Water Creek, along which are rather low bluffs in which the rocks are quite well shown from Nehawka to the vicinity of Wabash. Meek described a section on this creek called Cedar Bluff, about six miles above its mouth. The section had a thickness of 88+ feet, all of which he correctly referred to the Upper Coal Measures.[1]

The village of Nehawka is sixteen miles by rail northwest of Nebraska City and about one-half mile east of it is the Van Court and Lemist quarry which has been worked for six years. The floor of the quarry is between 90 and 95 feet, according to surveyor's level, above the Nehawka Railroad station, which makes its elevation 170 feet or more above the Missouri River level at Nebraska City, or approximately 1085 A. T.

SECTION OF THE NEHAWKA QUARRY.

		Ft.	In.		Ft.	In.
10.	Loess - - - - - - - - - - -	10		=	42	3
9.	Light gray to slightly bluish limestones that weather yellowish, all of which are worked for quarry stone. They are moderately fossiliferous, especially the shaly parts, *Athyris subtilita* being the most common - -	18		=	32	3
8.	Shaly limestones - - - - - - -	2		=	14	3
7.	Yellow shales that are used for bricks - - -	1		=	12	3
6.	Limestone used for bridges, the strongest in the quarry		10	=	11	3
5.	Yellowish shale used for vitrified bricks - -	1		=	10	5

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[1] Fin. Rep. U. S. Geol. Sur. Nebraska, pp. 97–99.

SECTION OF THE NEHAWKA QUARRY—*continued.*

		Ft.	In.		Ft.	In.
4.	Black shale that is quite bituminous	1	4	=	9	5
3.	Limestone, best building stone in quarry		7	=	8	1
2.	Limestones at base of quarry. Floor 90 to 95 feet above railroad level	1	6	=	7	6
1.	Yellow to buff arenaceous shales in railroad cut under quarry	6		=		6

The dip is small and toward the east. About twenty-two feet of the limestones are worked, the stone being crushed and used for railways and highways. Some of it is also burned for quicklime. The shale was formerly sent to Louisville, where it was burned for vitrified brick. There are some fossils in the upper limestones, especially in the shaly partings, yet, with the exception of *Athyris subtilita*, no species can be said to be abundant. These upper limestones, No. 9 of the section, furnished the following species:

Athyris (*Seminula*) *subtilita* (Hall) Newb. (aa).

Spirifer cameratus Morton (c).

Derbya crassa (M. & H.) H. & C. (r).

Productus (*Marginifera*) *longispinus* Sowb. (r).

Productus costatus Sowb. (?) (rr).

Productus semireticulatus (Martin) de Koninck. Fragment of specimen (rr).

Hypothyris (*Pugnax*) *uta* (Marcou) H. & C. (r).

Hustedia mormonii (Marcou) H. & C. (rr).

Meekella striato-costata (Cox) White & St. John (r).

Spirifer (*Martinia*) *lineatus* Martin (rr).

Lophophyllum proliferum (McChesney) Meek (c).

Zeacrinus (*?*) *mucrospinus* McChesney (rr).

Fusulina cylindrica Fischer (rr).

(?) *Chætetes* cf. *carbonarius* Worthen (r).

Coral or *sponge* sp. Large one, genus not yet determined (rr).

Crinoids. Fragments of stems (rr).

Naticopsis nana M. & W. Small and imperfectly preserved (rr).

On account of the faunal and lithologic character of the rock the above exposures are referred to the Wabaunsee formation. The quarryman reported an outcrop of coal in the bed of the creek near Nehawka and estimated that the bottom of the quarry was about 200 feet higher than the coal at Nebraska City.

Weeping Water.—This village is nine miles up the Weeping Water Creek from Nehawka, and for about seven miles the valley is bounded by low rounded bluffs. Beyond this the bluffs are steeper, their crest being formed by heavy limestones. This type of valley is conspicuously shown in the vicinity of the village, the sides of the bluffs being partly covered by large blocks of the massive limestone that have fallen from their original position. They continue steep, being marked by a prominent limestone stratum, for rather more than two miles above Weeping Water, when they again become lower with rounded slopes.

The first outcrop studied above the Nehawka quarry is seven miles up the Weeping Water valley, at a locality known as the "Swede quarry" on the north side of the Missouri Pacific Railway. It is only a few rods from the railroad, between twenty-five and thirty feet higher, with an approximate elevation of 1080 feet A. T.

SECTION OF THE SWEDE QUARRY.

	Ft.	In.		Ft.	In.
6. Massive yellowish to brownish gray limestone, that weathers whitish	1		=	18	9
5. Yellowish shale		10	=	17	9
4. Somewhat reddish limestone	1	4	=	16	11
3. Rather irregular, massive limestone, of yellowish to pinkish color, containing large numbers of *Fusulina cylindrica* Fischer, 2 to 2¼ feet thick. This limestone resembles somewhat the chocolate limestone of Swallow as it occurs along the Kansas valley near Maple Hill, Kansas	2	3	=	15	7
2. Yellowish soft shales, immense numbers of *Fusulina*. *Spirifer cameratus* is also common; 2½–3 feet thick	3		=	13	4
1. Massive limestone of rather light gray to buff color. The quarry rock. Flint in upper part of stratum and all of it quite free from fossils	10	4	=	10	4

The following species were collected in the above quarry, the greater number from the yellow shales of No. 2:

Athyris (*Seminula*) *subtilita* (Hall) Newb. (c).
Spirifer cameratus Morton (a).
Enteletes hemiplicatus (Hall) H. & C. (rr).
Productus semireticulatus (Martin) de Koninck (?). Only fragments (rr).
Chonetes granulifera Owen (rr).
Spiriferina kentuckensis Shum. (r).
Hustedia mormonii (Marcon) H. & C. (rr).
Rhombopora lepidodendroides Meek (c).
Lophophyllum proliferum (McChes.) Meek (rr).
Zeacrinus (?) *mucrospinus* McChesney (r).
Fusulina cylindrica Fischer. Very abundant in some shaly limestones (aa).
Campophyllum torquium (Owen) Meek (rr).
Phillipsia scitula M. & W. (rr).
Archæocidaris sp. Plate and spines (r).
Productus nebrascensis Owen (rr).
Fistulipora nodulifera Meek (c).
Crinoids. Segments of large stems (r).

The above fauna is that of the Wabaunsee formation and the reddish to pinkish limestones are similar in appearance to limestones near the middle of the formation in Kansas.

The heavy limestone near the crest of the bluff on the northern side of the creek is very prominent both above and below Weeping Water for some distance, as well as in the village itself. Perhaps the best section of the limestone and underlying rocks is afforded by the Reed quarry, one-half mile east of the village. It is north of the railroad, the base of the *Fusulina* shaly limestone being about eighty feet above railroad level or approximately 1160 feet A. T.

SECTION OF THE REED QUARRY.

	Ft.		Ft.
9. Loess, 10 to 12 feet - - - - - - -	12	=	63½
8. Massive light gray limestone weathering to a whitish color. This is the main quarry stone. It is crushed for railroad ballast and burned for lime which slacks and sets very quickly. In some places it reaches a thickness of 12 feet. Some flint and iron pyrites in upper part -	9	=	51½
7. Shaly buff to yellowish fossiliferous limestone containing abundant *Fusulinas* in the upper 4 feet and in lower part *Spirifer cameratus.* Used for riprap. Base about 80 feet above railroad level - - - - - -	6¾	=	42½

SECTION OF THE REED QUARRY—*continued.*

	Ft.		Ft.
6. Yellowish shale with plenty of *Spirifer cameratus*	1⅓	=	35⅚
5. Buff to yellowish limestone (not valuable) - -	1	=	34½
4. Black, bituminous shale - - - - - -	2	=	33½
3. Limestone quarried for building stone - - -	1½	=	31½
2. Greenish argillaceous shales - - - -	30±	=	30
1. Red shale, thickness undetermined. This stratum shows in the village and also in a railroad cut above it.			

The shaly yellowish limestone, No. 7, of this quarry contains quite a number of fossils, especially in its lower part. The following species were collected:

Athyris (*Seminula*) *subtilita* (Hall) Newb. (a).
Spirifer cameratus Morton (c).
Enteletes hemiplicatus (Hall) H. & C. (c).
Hypothyris (*Pugnax*) *uta* (Marcou) H. & C. (r).
Chonetes granulifera Owen (rr).
Productus longispinus Sowb. (rr).
Spirifer lineatus Martin (rr).
Spiriferina kentuckensis Shum. (rr).
Lophophyllum proliferum (McChes.) Meek (a).
Fusulina cylindrica Fischer. Abundant in some layers of the yellowish shales (aa).
Coral or *sponge* sp. Large, undetermined species (c.)
Chætetes cf. *carbonarius* Worthen (r).
Crinoid stems (rr).

The main quarry stone, No. 8, which is a very light gray compact limestone, contains but few fossils, except *Athyris subtilata* (Hall) Newb. Sections of this species, the interior of the shells filled with calcite crystals, are not uncommon in the limestone. In places there are crystals of iron pyrites, some of them large, that on weathering stain the stone as may be seen in some of the buildings in Weeping Water. The following species were collected in the massive limestone of the Reed quarry:

Athyris (*Seminula*) *subtilita* (Hall) Newb. (c). In the somewhat rough partings and apparently in the massive limestone.
Productus longispinus Sowb. (rr).

Meekella striato-costata (Cox) White & St. John (rr).
Lophophyllum proliferum (McChes.) Meek (rr).
Pleurotomaria sp. Small and imperfectly preserved (rr).
Crinoid stems. Some flint with iron in the limestones (rr).

This massive limestone, which from its great prominence in the vicinity of Weeping Water might be termed the Weeping Water limestone,[1] may be followed in the bluffs for three miles above Weeping Water. At the turn in the highway on the north side of the creek about halfway between Weeping Water and Wabash is the last exposure of the Weeping Water stone that was seen. The limestone at this locality is a light gray massive one that weathers to a whitish color, and closely resembles the heavy ledge in the vicinity of Weeping Water. Below are yellowish, shaly limestones with abundant specimens of *Fusulina cylindrica* Fischer, the same as in the Reed quarry. Estimated from one barometric reading, the elevation of the base of the above limestone is 1180 feet A. T., and as the base, in the Reed quarry, three and one-half miles to the east, is 1166 feet there is a dip of four feet per mile to the east. At this place the following species were collected from the Weeping Water limestone:

Athyris (*Seminula*) *subtilita* (*Hall*) Newb. (c).
Productus longispinus Sowb. (c).
Hypothyris (*Pugnax*) *uta* (*Marcou*) H. & C. (rr).
Productus pertenuis Meek (rr).
Meekella striato-costata (Cox) White & St. John (rr). Very imperfect specimen.

Dr. Hayden briefly described the Weeping Water stone as a "limestone, hard, whitish, and yellowish white; cropping out at the summits of the hills, and lying on the slopes in large masses eight to ten feet thick,"[2] accompanied by a rather general section of the bluff. He also described the following shaft beginning in the Weeping Water valley near creek level :

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[1] This is not intended as a formation name, but is merely used for convenience in speaking of this limestone stratum.

[2] Loc. cit., p. 14.

	Feet.		Feet.
9. Sandstones that form the creek bed	10	=	30
8. Slate and clay	3	=	20
7. Coal, nine inches	¾	=	17
6. Whitish, fire clay	3	=	16¼
5. Crystalline quartz, three inches	¼	=	13¼
4. Bluish clay	4	=	13
3. Whitish, fire clay	6	=	9
2. Red clay	3	=	3
1. Soft white limestone			

The above section is important from the fact that it shows a stratum of coal, nine inches thick, about 100 feet below the base of the Weeping Water limestone.

The very light gray to whitish color on the weathered surface of the Weeping Water limestone suggests at first the Permian limestones of Kansas, as, for example, the Strong flint at the base of the Chase formation; but the fauna, especially of the shaly limestones just below, indicates that they belong to the Wabaunsee.

One mile below Wabash, on the south bank of Weeping Water Creek, is the small Flowers' quarry.

SECTION OF FLOWERS' QUARRY.

	Feet.
4. Yellowish, coarse shales, containing plenty of fossils. Thickness not determined.	
3. Drab, compact limestone in three layers, containing a good many fossils, especially *Productus pertenuis* in the shaly parting,	3½
2. Thin layer of black bituminous shale,	5
1. Bluish coarse shales to creek level,	

The quarry stone, No. 3, has been worked to a limited extent for foundation stone. One reading of the barometer compared with the R. R. elevation at Weeping Water makes this limestone 1150 feet A. T. This indicates that it is below the Weeping Water stone, which is exposed two miles farther east on the north side of the creek. The following fossils were found in this limestone:

Spirifer cameratus Morton (r).
Chonetes granulifera Owen (r).

Productus pertenuis Meek (c).
Productus nebrascensis Owen (r).
Spiriferina kentuckensis Shum. (c).
Productus longispinus Sowb. (c).
Athyris (*Seminula*) *subtilita* (Hall) Newb. (c).
Hustedia mormonii (Marcou) H. & C. (rr).
Phillipsia scitula M. and W. (rr).
Rhombopora lepidodendroides Meek (rr).
Spirifer (*Martinia*) *planoconvexus* Shum. (rr).

The yellowish shales, No. 4, above the quarry stone have the following fauna:

Athyris (*Seminula*) *subtilita* (Hall) Newb. (aa).
Chonetes granulifera Owen (a).
Spirifer cameratus Morton (r).
Productus nebrascensis Owen (c).
Productus longispinus Sowb. (r).
Productus cora d'Orbigny (c). Perhaps one of the specimens is *P. costatus* Sowb. as it has a faint sinus.
Derbya crassa (M. & H.) H. & C. (c).
Productus pertenuis Meek (rr).
Productus semireticulatus (Mart.) de Koninck (rr).
Myalina swallowi McChesney (r).
Myalina subquadrata Shum. (rr).
Myalina perattenuata M. & H. (rr).
Myalina kansasensis Shum. (?) (rr). Small specimen. Characters not clearly shown.
Fusulina cylindrica Fischer (aa). In some layers of the yellowish shales.
Aviculopecten occidentalis (Shum.) M. & W. (rr).
Rhombopora lepidodendroides Meek (r).
Lophophyllum proliferum (McChes.) Meek (rr).
Septopora biserialis (Swallow) Waagen (r).
Zeacrinus mucrospinus McChesney (rr). Calyx and spine.
Crinoids (r). Segments and parts of quite large stems.

These were the last rocks found in place along Weeping Water Creek which are shown by their fauna to belong in the Wabaunsee formation.

One mile to the west of Wabash and rather more than 100 feet higher than the Flowers' quarry, the general level of the upland is reached. There are very few exposures on these higher slopes along the upper part of the Weeping Water valley, the country being gently rolling and the rocks deeply covered by loess and soil. According to a residing farmer on this upland, a well fifty-six feet deep did not strike hard rock but was dug "in dirt" for its entire depth.

Louisville.—Ten miles due north of Weeping Water is Louisville on the Platte River. The Missouri Pacific Railroad station is 1042 feet A. T. or thirty-eight feet lower than that at Weeping Water. The Platte River is shallow, with numerous sand bars, and at this locality is nearly one-half mile wide, lined on both sides with moderately steep bluffs. In these bluffs, both above and below the town, are a number of quarries which have been or are extensively worked and so afford an excellent idea of the geology of this region. On the south side of the river are several quarries and a section of one, the Parmlee, about three-fourths of a mile west of the town and south of the B. & M. R. Railroad was measured. According to the barometer, the floor of this quarry is some sixty feet above the Platte River which makes it approximately 1070 feet A. T.

THE PARMLEE QUARRY SECTION:

	Ft. In.		Ft. In.
8. Loess	10±	=	32 8
7. Rather rough light gray to yellowish, very fossiliferous limestone	3 6	=	22 8
6. Yellow, very fossiliferous clay shales. *Spirifer cameratus*	1 2	=	19 2
5. Light gray limestone, not in western part of quarry	2	=	18
4. Green argillaceous shales	6	=	16
3. Red or maroon argillaceous shales	6	=	15 6
2. Rather shaly, slightly greenish limestone and shale	2 6	=	9 6
1. Quite massive light gray limestone, somewhat fossiliferous. Quarry stone. Bottom of quarry approximately 1070 feet A. T.	7	=	7

The massive limestone, No. 1, of the Parmlee quarry, contains some fossils, the larger number of specimens occurring in the somewhat shaly partings. The following species were obtained:

Athyris (*Seminula*) *subtilita* (Hall) Newb. (a).
Productus longispinus Sowb. (c).

Productus nebrascensis Owen (rr).

Spiriferina kentuckensis Shum. (rr).

Fusulina cylindrica Fischer (a). Abundant in certain layers.

Archæocidaris sp. (rr). Spine.

Bellerophon carbonarius Cox (?) (r). Imperfectly preserved specimens of the size and shape of this species; one specimen shows concentric striæ that are not mentioned in the description.

Crinoids. (c). Segments of stems.

The yellow shales, No. 6, contain a larger number of species and more numerous specimens. The list is as follows:

Athyris (*Seminula*) *subtilita* (Hall) Newb. (c).
Chonetes verneuiliana N. & P. (aa).
Chonetes granulifera Owen (c).
Productus longispinus Sowb. (rr).
Productus nebrascensis Owen (r).
Spirifer (*Martinia*) *planoconvexus* Shum. (r).
Spirifer cameratus Morton (r).
Derbya crassa (M. & H.) H. & C. (rr).
Spiriferina kentuckensis Shum. (rr).
Lophophyllum proliferum (McChes.) Meek (rr).
Rhombopora lepidodendroides Meek (c).
Septopora biserialis (Swallow) Waagen (c).
Chætetes cf. *carbonarius* Worthen (rr).
Scaphiscrinus (?) *hemisphæricus* (Shum.) Meek (r).
Crinoid, loose plates and also segments of stems.

Along the bluff on the northern side of the Platte River, opposite the Parmlee quarry, in Sarpy county, are several quarries that afford excellent exposures. These quarries contain reddish shales above the light gray limestone and when seen from the southern side of the river in bright sunshine form a very striking feature of the landscape. The Rock Island railroad follows the valley just below the bluff and the quarries have been worked extensively for both building stone and rock ballast. The Green quarry, near the eastern end of the quarries, gives a good section from a little above the railroad level nearly to the crest of the bluff. It may be considered as divided into a lower and an upper section, separated by thirty-nine feet of covered slope. A few rods to the east is another small quarry in rocks belonging to the same strata as those of the lower Green quarry.

SECTION OF THE GREEN QUARRY.

		Ft.		Ft.
16.	Soil containing bowlders of Dakota sandstone 2 to 3 feet thick	3	=	112½
15.	Light gray sandstone	5+	=	109½
14.	Shale with abundant ferruginous concretions (probably the base of the Dakota sandstone)	½	=	104½
13.	Brownish yellow shales containing large flint pebbles mixed with others	1	=	104
12.	Yellowish brown shale	1	=	103
11.	Red shale more compact than that in the Parmlee quarry on the south side of the Platte River	4	=	102
10.	Yellowish shaly limestones	4	=	98
9.	Gray limestone, in some places very light gray and in others yellowish. Fossiliferous (same as quarry stone No. 7 of Parmlee quarry on south side of the Platte)	7	=	94
8.	Covered slope	39	=	87
7.	Brownish yellow limestone that weathers to an ochre color. Contains large numbers of fragments of shells	2	=	48
6.	Very yellow soft shales	3+	=	46
5.	Grayish, somewhat shaly limestone	1+	=	43
4.	Massive grayish limestone with brownish specks and blotches. Some *Fusulinas* and other fossils. Lower part brownish-red in places	6½	=	42
3.	Yellowish shaly limestone and shales	1½	=	35½
2.	Light gray to drab and bluish limestone; the upper part is more shaly. Contains fossils, especially *Athyris subtilita*	12	=	34
1.	Covered slope, level of Platte River, near 1010 feet A. T.	22	=	22

The limestones, Nos. 2 and 9, of the above section are quite fossiliferous, especially the more shaly layers. In No. 2 the following species were collected:

Athyris (*Seminula*) *subtilita* (Hall) Newb. (a).
Spirifer cameratus Morton (r).
Productus costatus Sowb. (r).
Productus longispinus Sowb. (rr).
Productus nebrascensis Owen (rr).

Productus semireticulatis (Mart.) de Kon. (?). Imperfectly preserved (rr).
Spiriferina kentuckensis Shum. (rr).
Fistulipora nodulifera Meek (rr).
Fusulina cylindrica Fischer (r).
Zeacrinus (?) *mucrospinus* McChesney (rr).
Archæocidaris sp. Spines (rr).
Crinoids. Large column (rr).

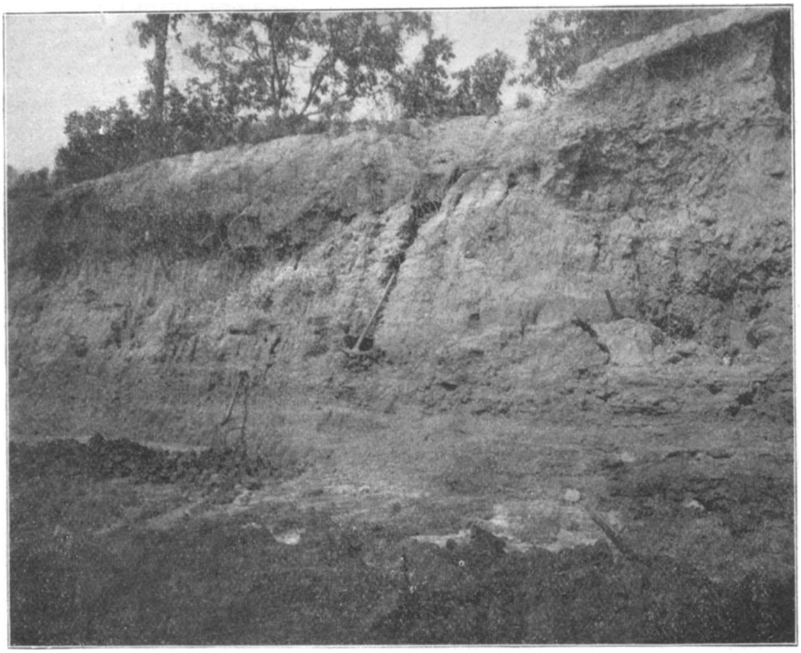

FIG. 2. View in western part of Green quarry north of Platte River at Louisville, showing line of unconformability between Dakota sandstone and Carboniferous limestone. The hammer marks the limestone, No. 3 of section, on which the Dakota sandstone rests, and only three feet to the west, marked by the pick, the limestone is wanting and the Dakota rests on shales of No. 2.

The shaly layers of No. 9 did not furnish as large a number of species as No. 2, though the first two species of the following list were more abundant in the upper than in the lower limestone. The fauna is :

Athyris (*Seminula*) *subtilita* (Hall) Newb. (a).
Productus longispinus Sowb. (c).

Productus costatus Sowb. (rr).
Productus semireticulatus (Mart.) de Kon. (rr).
Spiriferina kentuckensis Shum. (rr).
Derbya crassa (M. & H.) H. & C. (rr).
Archæocidaris sp. Plate and spines (r).

A little farther west in the upper Green quarry is an excellent exposure that differs somewhat from the one just described The section is as follows, commencing at the top of the red shales, No. 11, of the eastern part of the Green quarry:

	Ft.	In.		Ft.	In.
6. Soil	1		=	10	5
5. Light gray to whitish arenaceous deposit (very friable sandstone probably belonging to the Dakota)	5	6	=	9	5
4. Dark to yellowish brown sandstone; base of Dakota sandstone. Prominent line of unconformity		8	=	3	11
3. Massive light gray limestone	1	3	=	3	3
2. Yellowish and greenish shales,	2		=	2	
1. Top of the red shales (No. 11 of the eastern part of the quarry).					

This part of the quarry shows very clearly the line of unconformity due to erosion between the Carboniferous (Wabaunsee) and Cretaceous (Dakota) systems. In places the dark brown Dakota sandstone rests on the gray limestone, No. 3; while not more than three feet away the gray limestone is entirely absent, having been worn away before the deposition of the Cretaceous, and the Dakota sandstone rests on the yellowish shales, No. 2, of the section. When this section was studied the upper rocks for several rods had been recently removed, so that the several strata and the line of unconformity were clearly shown. The line of unconformity is shown in the accompanying picture, where the small hammer shows the Dakota resting on the limestone of No. 3, and the pick shows it resting on the shales of No. 2. Many of the large blocks of rock from the wall of the quarry showed clearly the line of contact, the non-calcareous brown Dakota sandstone closely united to the yellowish calcareous shales in which were fragments of shells. A few rods west of the quarry just described, and across a small run, is another large quarry called the Cooley, which gave the following section:

		Ft. In.		Ft. In
11.	Soil,			
10.	Light gray compact limestone	1	=	30
9.	Red shale in upper part, green shale in lower part	2 6	=	29
8.	Very compact light gray limestone, with some flint	1 6	=	26 6
7.	Coarse, grayish shale	1	=	25
6.	Greenish argillaceous shale	3 6	=	24
5.	Massive grayish compact limestone, with fossils	2 4	=	20 6
4.	Yellowish shales that are greenish at the base	2	=	18 2
3.	Red, argillaceous shales	6 6	=	16 2
2.	Shaly grayish and yellowish limestones changing to shales	2 6	=	9 8
1.	Massive, grayish limestone (bottom of the quarry,)	7 2	=	7 2

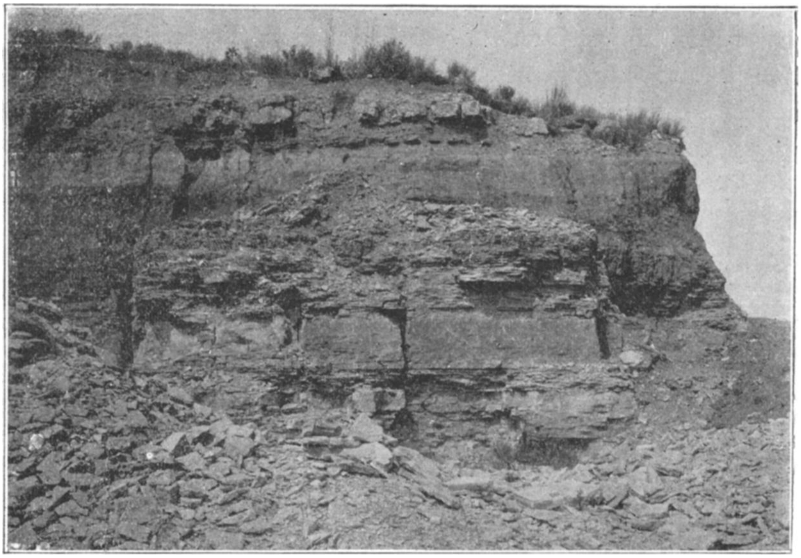

FIG. 3. View in eastern part of Cooley quarry, north of Platte River at Louisville Nos. 1–5 of the section are shown.

From the somewhat shaly layers of No. 1 of this quarry the following fossils were collected:

Athyris (*Seminula*) *subtilita* (Hall) Newb. (r).
Productus costatus Sowb. (rr).
Productus cora d'Orbigny (r).

Myalina cf. *recurvirostris* M. & W. (rr). Beak is gone and the specific identification is not positive on that account.

The rocks at the eastern end of this quarry are well shown in Fig. 3 of the pictures, the heavy stratum near the bottom of the picture forming the top of No. 1, which is succeeded by Nos. 2–5 of the section.

The quarry limestone, No. 1, of the above quarry is the same stratum as No. 9 (the quarry limestone) in the eastern part of the Green quarry. The yellowish shales, Nos. 12 and 13, of the eastern part of the Green quarry, No. 2 of the western part, and No. 4 of the Cooley quarry are the same stratum. In the Green quarry the Dakota sandstone rests on either these yellowish shales or the overlying limestone (No. 3) of the western part of the Green quarry; but in the Cooley quarry there is no Dakota sandstone, though Carboniferous rocks with a thickness of eleven feet ten inches are shown above the yellowish shales. In the Green quarry these rocks, with the exception of the limestone, No. 3, in its western part, were eroded before the deposition of the Dakota sandstone. The above data obtained on comparing the Cooley and Green quarries show that the Dakota sandstone was deposited in a very irregular Carboniferous floor.

The massive quarry limestone in the quarries north of the Platte River, No. 9 of the Green and No. 1 of the Cooley, is the same stratum as that quarried in the Parmlee quarry, No. 1, on the south side of the river. The difference in elevation of the base of this limestone on opposite banks of the river, 1097 feet A. T. on the north side, and 1070 on the south side, may be due partly to an error in the barometric record, though there is probably some dip in that direction. In the Parmlee quarry fifteen feet, eight inches of Carboniferous rocks are exposed above the top of the quarry limestone, No. 1 of the section, without showing the Dakota; in the Cooley twenty-three feet are exposed, and in the eastern part of the Green quarry there are ten feet capped by the Dakota. This comparison between the north and south sides also shows the irregularity of surface upon which the

Dakota sandstone was deposited. Dr. Hayden saw the contact of the Carboniferous and Cretaceous rocks; but apparently at localities where there is not such a clear line of unconformity, for he said: "We find at one or two localities the Cretaceous and Carboniferous beds in apposition; and though the eye can observe no apparent want of conformity in these beds, yet we can readily imagine the tremendous effects of the erosion prior to the deposition of the sandstone, from the fact that hundreds of feet of clays and limestones must have been swept away."[1]

In the lower limestone, No. 2, of the Green quarry are specimens of *Spirifer cameratus* associated with other species of the Wabaunsee formation; while in the Parmlee quarry a similar fauna with *Spirifer cameratus* is found in the yellowish shales, No. 6, above the quarry limestone. On account of this fauna and their stratigraphic position, all of the Carboniferous rocks in the vicinity of Louisville are referred to the Wabaunsee formation. On the Platte River, the Permian is not represented and the Dakota sandstone rests unconformably on the limestones and shales of the Wabaunsee formation. This is consequently a very important section as it shows that the 800 feet of Permian rocks exposed along the Kansas and Smoky Hill rivers in Kansas have disappeared and the Dakota sandstone of the Cretaceous system rests on the Wabaunsee formation of the Missourian series or Upper Carboniferous. This conclusion agrees with that of Dr. Hayden who on his "Geological Map of Nebraska" published in 1858 represented the Lower Cretaceous (now known as the

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[1] Fin. Rep. U. S. Geol. Sur. Nebraska, p. 9. Also on p. 8 is the statement that "near the old Otoe village, eight miles above the mouth of the Platte [is] a good exposure of the sandstone resting conformably on the Carboniferous limestone." As early as 1858 Meek and Hayden reported the Cretaceous sandstone on the Platte River as resting "directly upon Carboniferous rocks" near the mouth of the Elk Horn River which is some twenty miles above Louisville (Proc. Acad. Nat. Sci. Phil., Vol. X, p. 259). However, it appears that in these early explorations of Meek and Hayden they did not recognize the unconformity between the Carboniferous and Cretaceous for in January 1859, they published the following statement: "In conclusion we would state that there is no unconformability so far as our knowledge extends, amongst all the rocks of Nebraska and northeastern Kansas, from the Coal Measures to the top of the most recent Cretaceous" (Am. Jour. Sci., 2d ser., Vol. XXVII, p. 35).

Dakota sandstone) on the Platte River as resting on the Carboniferous.[1] On this map the Permian was represented as thinning out and disappearing at a locality apparently several miles north of Dunbar and northwest of Nebraska City; while in the report of 1872 Dr. Hayden clearly expressed this conclusion in describing the geology of Douglas and Sarpy counties. Dr. Hayden said: "If the Permo-Carboniferous and the Permian were ever deposited over this area, they were swept away by erosion prior to the deposition of the Cretaceous rocks. If we follow the valley of the Platte westward on the northern side, we shall see the junction of the two great periods, Carboniferous and Cretaceous, and we shall find that the beds of the Dakota group, or what we suppose to be the Lower Cretaceous beds of the west, rest directly down on the limestones of the Upper Coal Measures."[2] There seems to have been some error in coloring the geological map accompanying this report, for on it the Permian is represented as reaching the Platte valley at Saline, now called Ashland, thirteen miles above Louisville, and then extending up the Platte some twenty miles to Fremont. As a matter of fact along the river to the east of Ashland are fine exposures of the Dakota sandstone.

Meek described a section of rocks on the north side of the Platte River between three and four miles above its mouth (about ten miles northeast of Louisville) which by their fossils are shown to belong to the Upper Carboniferous, probably the Wabaunsee formation.[3]

On the ridge to the south of Louisville are exposures of the lower part of the Dakota formation. One of these is in the "Fire Clay" quarry of Captain Hoover, one and one-half miles south of the village (Sec. 27, Tp. 12, Range 11) where an opening of about fifty feet has been made in working the middle part of the section for fire clay. The exposure begins on the bank of a small run with an approximate altitude of 1100 feet A. T.

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[1] Proc. Acad. Nat. Sci., Phil., Vol. X.

[2] Fin. Rep. Geol. Sur. Neb., p. 7.

[3] *Ibid.*, pp. 90–93.

SECTION OF CAPTAIN HOOVER "FIRE CLAY" QUARRY.

	Feet.
7. Soil containing bowlders of hard, dark brown Dakota sandstone	1 = 53
6. Light brown to rusty brown color friable sandstone with streaks of iron brown. In the upper part, some of the hard, dark brown sandstone (line of irregular bedding)	14 = 52
5. Brownish friable sandstone, six inches to two and one-half feet thick, the difference in thickness being due to the irregular line limiting the top of this stratum	2½ = 38
4. Very hard dark brown sandstone	½ ± = 35½
3. Brown conglomerate with plenty of small pebbles of quartz, flint, etc.	½ = 35
2. Somewhat arenaceous fire clay of light gray to almost white color with pinkish layers. Some layers of friable light gray to whitish sandstone; also of brownish yellow color. About fifteen feet of this part of the section used for fire clay	30 = 34½
1. Yellowish, very soft and friable sandstone with dark brown streaks (bottom of exposure below the quarry)	14½ = 14½

In the other quarry of Captain Hoover (Sec. 23, Tp. 12, Range 11) the Dakota sandstone has been quarried and used to a considerable extent in the village buildings. The stone out of which Captain Hoover's house was built some thirty years ago has hardened somewhat on exposure, and in many of the blocks the marks of the tools used in dressing may still be seen. According to the Captain there is about twenty feet of this dark brown sandstone that may be quarried. It is interesting to note the difference in consolidation of the same layers of the Dakota sandstone when separated by only a short distance. The Hoover quarries are only about one-half mile apart and still the comparatively massive brown quarry sandstone just described is the same stratum as the friable light brown sandstone, No. 6, of the "Fire Clay" quarry.

Below the sandstone on section 23 is from fifteen to twenty feet of the light gray to pinkish fire clay. The clay from both of these quarries is made into pottery and is also used in Union Pacific foundry shops and for crucibles and the lining of retorts in smelters. A considerable amount of it is shipped to Omaha for use in the gold and silver smelters. Samples were shown me of similar colored fire clay from a pit near the edge of the village. The conglomerate stratum, No. 3, of the "Fire Clay" quarry is also present at the base of the sandstone in the Hoover sandstone quarry. Near Captain Hoover's house, below the sandstone and fire clay, the Wabaunsee limestone is shown; but the contact between the Wabaunsee and Dakota formations is covered by soil.

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UNION COLLEGE,
Schenectady, N. Y., October 1896.